

1
2 PROCESS FOR FABRICATING OF A SPEAKER ENCLOSURE HAVING
3 ANY PRESELECTED EXTERNAL SHAPE CONTAINING
4 INTERNAL CAVITIES SHAPED WITH PRESELECTED ENHANCEMENTS FOR
5 EACH PRESELECTED DRIVER MOUNTED WITHIN SAID EXTERNAL SHAPED
6 ENCLOSURE

7 **BACKGROUND OF THE INVENTION**

8 FIELD OF THE INVENTION

9 This invention relates to the art of designing
10 and fabricating an enclosure for a speaker driver or set of
11 drivers and more particularly providing the ability to
12 produce any preselected external shape of the enclosure
13 independently of the selected driver(s) while including the
14 fabricating of internal cavities with selected shapes
15 and/or positioned ports and connecting channels thereby
16 allowing said internal cavities of said enclosure to
17 provide enhancement ability for the reproduction of sound
18 of the selected driver(s). This application is based upon
19 the Provisional Patent filed 07/31/02 as Serial Number
20 60/400,459.

21 Description of the Prior Art

22 The art of designing and fabricating an enclosure
23 for a speaker driver or set of drivers has a long history
24 and many variations. As speaker enclosures have evolved
25 from a simple box for one driver or for a set of drivers,
26 the box has evolved to accommodate each driver or set of
27 drivers. Each change in driver technology and the
28 enhancement in performance has resulted in the inclusion of
29 ports, open, closed or tuned, enclosures and placement of
30 sound absorption material around or behind the speaker
31 driver, separation of the box into compartments, and other
32 accommodations and improvements such as supports to stiffen
33 the box. However, none of teaching of the prior art
34 improvements suggest substantially changing the outside
35 shape of the box, which may also accommodate a modified
36 inside shape as required for a driver selection. This

1 invention solves the problem of allowing any selected
2 outside shape to accommodate the esthetic design of the
3 environment into which the speaker is placed as well as
4 accommodate any inside shaping required to enhance the
5 characteristics of the drivers selected to be incorporated
6 into the speaker enclosure.

7 Of the hundreds of speaker enclosures offered,
8 most are based upon a box incorporating the basic square,
9 rectangle, triangle or trapezoid shape. One prior art
10 publication describes an enclosure incorporating a curved
11 top and a rounded bottom formed from a circular box and a
12 rectangular box with one end rounded, both component shapes
13 being formed of layers of material glued together. The base
14 of the rectangular box unit is then glued to the top of the
15 circular box unit to complete the fabrication of the
16 enclosure. This article appeared in "SPEAKER BUILDER, THE
17 LOUDESPEAKER JOURNAL", TWO:2000 in an article titled
18 "Danish Delight". However, assembly of the device as
19 taught by the article with glue is a problem because as the
20 glue holding the layers and separate units together ages,
21 the environment of vibration of the speakers within the
22 separate shapes used as parts to fabricate the enclosure
23 for the selected drivers will result in separation of the
24 parts and the layers used to form the parts. Any
25 separation will induce undesired vibration that will
26 generate distortion of the sound reproduction capability of
27 this device. This article does not even suggest any
28 provision for supports within the individual units nor
29 incorporating any strengthening ribs or baffles. The
30 shapes are made from thin sheets of material that are glued
31 together without any additional means to hold the layers
32 together. Nor does the article provide for securely
33 attaching the individual shapes together. As the glue
34 becomes brittle, and as the individual units are heated and
35 cooled in the environment the layers will expand and
36 contract or as the units are moved and positioned within

1 the listening environment the individual pieces will also
2 tend to become separated. Any separation will create
3 unwanted vibrations and distortion of the sound
4 reproduction ability of the speaker assembly.

5 Another example of a speaker assembled from
6 layers is taught by United States Patent 5,900,594 ('594)
7 with the technique of cutting concentric shapes from a
8 single sheet, making the cuts at a 45 degree angle,
9 thereafter placing the inner layer upside down on the next
10 layer and so on and then adding another layer cut from a
11 second board as a cap to form an enclosure. The speakers
12 are mounted on the second board. '594 does not teach or
13 suggest shapes beyond basic conical shapes nor does '594
14 suggest the addition of more than the basic chamber created
15 by the enclosure. '594 teaches the use of glue to hold the
16 layers together without reinforcement, baffles, or supports
17 to prevent separation of the layers. The use of internal,
18 concentric layers produces minimal overlap of the layers
19 that precludes the use of reinforcement rods in the
20 perimeter of the device to hold the layers in place.

21 The present invention solves these problems by
22 teaching the integration of any shapes into a single unit
23 that incorporates supports and baffles as well as surfaces
24 to enhance the music reproduction all within a unified,
25 reinforced unit that is not prone to separation of units
26 with age thereby avoiding the production of unwanted
27 vibration and rattles that change the sound reproduction
28 ability of the units.

29 Nothing is taught by the prior art for the
30 construction of outside shapes other than ordinary
31 geometric shapes with sharp corners that may reflect and
32 distort the sound.

33 The prior art does teach construction of layers
34 set side by side such as a cutting board that may
35 incorporate reinforcement to prevent splitting and warping
36 due to moisture. However, the prior art teaching of

1 speaker enclosures provides only limited teaching for
2 reinforcement of the conventional boxlike construction of
3 the enclosure to reduce vibration.

4 The present invention is using an old method of
5 construction by layers for the new use in addition to the
6 incorporation of selected outside and inside shapes as well
7 internal supports, baffles, tuning ports, channels and
8 equipment compartments all in a reinforced, rugged unitary
9 unit.

10 Thus, there has long been a need for a method of
11 fabrication of a speaker enclosure arrangement that allows
12 the user to easily define an external shape for the
13 proposed environment as well as incorporate preselected
14 drivers.

15 It is desired that the method allow a full range
16 of external and internal design to accommodate the user's
17 unique needs.

18 It is further desired that the method produce
19 identical reproductions should the user require more than
20 one unit or even to mass-produce the unit after completion
21 of the design stage.

22 It is further desired that the method allow ease
23 of alteration to the external or internal surface to
24 incorporate changes to enhance external appearance or to
25 fine-tune any internal cavity or port placement for
26 enhancement of performance without major retooling.

27 It is further desired that the device be produced
28 by the method not be adversely affected by a build up of
29 separation of individual layers due to changes in the
30 environment such as temperature or humidity.

31 It is further desired that the device produced by
32 the method not require maintenance or retightening of the
33 reinforcement.

34 It is desired that a simple attachment of the
35 speaker terminals to the output of the user's equipment and
36 placement of the speaker units within the user's

1 environment, adjustment of cross over network, if any, by
2 external knobs, is provided, for such user preference
3 characteristics as balance or tuning, be all that is
4 required to install and use the enclosures.

5 It is further desired that the enclosure device
6 produced by the method of this invention incorporate any
7 required mechanical or electronic interface to easily adapt
8 to and reduce losses when attached to the user's equipment.

9 It is further desired that the external surface
10 of the enclosure device produced by the method of this
11 invention be enhanced with a veneer of preselected material
12 to present an attractive, finished, unit compatible with
13 the other furnishings within the user's environment without
14 detracting from the sound reproduction abilities of the
15 device.

16 SUMMARY OF THE INVENTION

17 Accordingly, it is an object of the present
18 invention to provide a method for integrating the
19 fabrication of a preselected outside surface completely
20 enclosing the chambers, channels, baffles, ribs, and
21 stiffeners desired to support and enhance a set of
22 preselected drivers to produce sound having preselected
23 characteristics with a minimum of distortion and extraneous
24 vibration.

25 It is an object of the present invention to
26 provide an improved fabrication method that allows the user
27 to initially adjust any of the elements of the enclosure
28 and thereafter allow the user to duplicate the entire
29 design to create matched sets that do not require any
30 further response testing or adjustment to any of the
31 elements.

32 It is a further object of the present invention
33 to provide an enclosure having an outside surface with a
34 preselected finish and appearance that is compatible with
35 other furnishings within the users environment.

1 It is another object of the present invention to
2 provide a method of fabrication that produces an end
3 product that may be repositioned within the users
4 environment and that resists separation of individual
5 layers due to changes of temperature and humidity within
6 the users environment.

7 It is yet another object of the present invention
8 to provide a method of fabrication of the external shape
9 desired by the user that incorporates the set of drivers
10 compatible with the user's requirement for power generation
11 and frequency response in as many identical or similar
12 units as desired by the user.

13 It is further desired that the user not be
14 required to adjust the support, reinforcement or
15 characteristics of the device to maintain the desired
16 frequency response other than simply adjust any external
17 knobs to change the settings of internal crossover
18 electronics or other similar elements incorporated in the
19 device after attachment of the input signal as provided by
20 the user's equipment to the externally mounted terminals
21 for the drivers.

22 The above and other objects of the present
23 invention are achieved, according to a preferred embodiment
24 thereof, by providing an improved method of fabrication by
25 means of individual layers of preselected thickness and
26 circumference shape. Each layer further incorporating
27 internal cutouts and alignment guide holes such that the
28 assembly of the layers by alignment of the guide holes from
29 layer to layer creates the desired outside shaped surface
30 and includes preselected internal chambers, baffles,
31 supports, tuning ports, equipment compartments and channels
32 all in a unified device capable of sound reproduction under
33 the condition of the user positioning the device within the
34 user's environment and applying audio signal to the
35 external terminals mounded on the device.

1 A further step of applying an additional front
2 layer incorporating screen and a layer of veneer to the
3 other surfaces may be added to the assembly to produce a
4 finished, furniture-looking device.

5 The present invention is an improved fabrication
6 method using a plurality of templates as a pattern to
7 reproduce the device, each template corresponding to a
8 "slice" of the object to be fabricated. The thickness of
9 the "slice" or layer generally corresponds to the thickness
10 of the sheet stock from which the layer is cut. The
11 preselected external circumferential shape edge and
12 preselected internal circumferential edges is applied to
13 each template. The cutting of the sheet stock along the
14 applied edges may be made by band saw, automated router
15 machine, laser or other cutting method to produce a clean
16 cut without raised edges that may interfere with the side-
17 by-side assembly of layers. If any raised edges appear in
18 the process, they should be sanded smooth to insure each
19 layer will tightly fit next to the adjacent layer. The
20 angle of the cut through the stock may be at 90 degrees or
21 beveled at an angle so that as the layers are assembled
22 side by side and the edges are in general alignment. In
23 the preferred embodiment the angle of cuts of external or
24 internal circumferential edges are preformed at a 90 degree
25 angle to the parallel surfaces of the sheet material.
26 Further, the external and internal circumferential edges
27 are aligned within 1/32 of an inch from one to another
28 adjoining template sheet. Thus, the external and internal
29 circumferential edges as the templates are assembled side-
30 by-side form as a smooth curved surface rather than a step-
31 wise approximation of the desired internal or external
32 surface. Of course, if a complex shape is desired at some
33 portion of the interior or external circumferential edge, a
34 thinner stock utilizing more layers may be utilized to
35 assemble the object with smother assembled edge surfaces

1 without the need for beveling or extensive edge processing
2 after assembly of the layers.

3 In the preferred method, the method uses a number
4 of templates forming each layer to define the external
5 circumferential shape and any internal cutouts to define
6 the internal circumferential shape of cavities, channels as
7 well as supports and alignment guide holes. The templates
8 are used to pattern a specific layer or slice of the
9 desired final device. The layers are assembled by
10 alignment of the alignment guide holes and thereafter a
11 metal shaft having threaded ends and a nut on each end is
12 inserted within the alignment guide holes to apply pressure
13 to the layers by means of tightening the nuts thereby
14 holding the layers together. This method allows the
15 present invention to adept the outside shape and internal
16 chambers and channels to reproduce music.

17 BRIEF DESCRIPTION OF THE DRAWINGS

18 The above and other embodiments of the present
19 invention may be more fully understood from the following
20 detailed description, taken together with the accompanying
21 drawings, wherein similar reference characters refer to
22 similar elements throughout, and in which:

23 Figure 1 is a plane view of a general shaped
24 template of the preselected desired external
25 circumferential shape with guide holes;

26 Figure 2 is a plane view of a general shaped
27 template with guide holes and internal circumferential
28 shapes for cavities and channels;

29 Figure 3 is a plane view of a general shaped
30 template with guide holes and internal circumferential
31 shapes for cavities, channels and supports;

32 Figure 4 is a plane view of a general shaped
33 template with guide holes and an internal circumferential
34 shape for a separation layer;

35 Figure 5 is a plane view of a general shaped
36 template with guide holes, an internal circumferential

1 shape for a port but no other internal circumferential
2 shapes for an internal termination layer;

3 Figure 6 is a plane view of a general shaped
4 template with guide holes and a general internal
5 circumferential shape for a separation layer;

6 Figure 7 is a plane view of a general shaped
7 template with countersunk guide holes and no internal
8 circumferential shape for a termination layer;

9 Figure 8 is a perspective view of general shaped
10 template layers with guide holes aligned showing internal
11 cutouts forming channels, cavities, ports, supports and
12 termination layers;

13 Figure 9 is top view of Figure 8 of assembled
14 layers;

15 Figure 10 is a cross sectional view of Figure 9
16 along a-a of the assembled layers; and,

17 Figure 11 is a perspective view of the
18 reinforcing bar with threaded ends.

19 DESCRIPTION OF A PREFERRED EMBODIMENT

20 Referring now to the drawing, Fig. 1 shows the
21 general circumferential shape 101 preselected to be the
22 external shape of the enclosure fabricated according to the
23 teaching of this invention. A preselected number of guide
24 holes 105 are marked on this general template.

25 Figure 2 shows the general template with internal
26 circumferential shapes for a woofer cutout edge 102, mid-
27 range cutouts edges 103, a port cutout edge 104 and a
28 tweeter cutout edge 106 for the preselected set of drivers
29 to be mounted within the assembled enclosure. The guide
30 holes 105 set out on the general template of Figure 1 are
31 applied to the template of Figure 2 to assist in alignment
32 of the templates into the final assembled enclosure.

33 Figure 3 shows the general template with guide
34 holes 105 and an internal support 107 placed between
35 chambers formed by internal circumferential edges 116 so as
36 to not interfere with the mounting of the mid-range and

1 tweeter drivers within the chamber formed by internal
2 circumferential edges 103 and 106 respectively. Internal
3 circumferential edge 104 continues the formation of the
4 port chamber and internal circumferential edge 102
5 continues the formation of the chamber into which the
6 woofer driver is to be mounted.

7 Figure 4 shows the general template with guide
8 holes 105, a continuation of the internal circumferential
9 edge 104 forming the port and internal circumferential edge
10 102 forming the chamber for the woofer with a general
11 internal circumferential edge 117 that forms an internal
12 chamber behind the mid-range mounting edges 103 and tweeter
13 mounting edges 106 to form the preselected volume to
14 enhance the performance of the preselected drivers.

15 Figure 5 shows the general template with guide
16 holes 105, a continuation of the internal circumferential
17 edge 102 for the woofer chamber and internal
18 circumferential edge 104 for the port but no other internal
19 circumferential edges to terminate the formation of the
20 chamber tuned for the mid-range and tweeter drivers.

21 Figure 6 shows the general template with guide
22 holes 105 and only one general internal circumferential
23 edge 109 to be used as a spacer layer to extend the
24 chambers initiated for the port by edge 104, for the woofer
25 by edge 102, for the mid-range by edge 103 and for the
26 tweeter by edge 106 as required to produce the preselected
27 chamber volumes to enhance the music reproduction of the
28 preselected set of drivers mounted within the enclosure.

29 Figure 7 shows the general template with guide
30 holes 105 that may be countersunk with edges 113. No
31 internal circumferential edges are cut into this template
32 so that it may be used as a terminal layer for the back of
33 the enclosure.

34 Figure 8 is a perspective view of multiple layers
35 placed side by side for assembly. The layers may be
36 assembled in this order or may be rearranged into another

1 order as the testing for response of the enclosure is
2 conducted. However, the general order is a front layer as
3 depicted in Figure 2 labeled (A), a terminal layer as
4 depicted in Figure 7 labeled (F) and intermediate layers
5 labeled (B), (C), (D) and (E) forming the internal
6 cavities, ports and channels with supports all spaced apart
7 and aligned with the guide holes 105. Another possible
8 arrangement of layers shown in Figure 8 is A, B, B, B, C,
9 B, B, B, C, B, B, B, C, B, B, B, D, B, B, E, C, E, E, E, F,
10 F that is used in the preferred embodiment of this device.

11 As shown in Figure 8, the individual layers of
12 the stack 101 have a preselected circumferential shape 101
13 that defines the external shape of the enclosure. The
14 internal guide holes 105 assist in the assembly of the
15 enclosure. Alignment of the guide holes 105 in each of the
16 adjacent layers forms the preselected external shape and
17 preselected internal chambers and channels. A plurality of
18 reinforcing rods 110 shown in Figure 11, having threaded
19 ends 111 are inserted into each guide hole to assist the
20 alignment of the layers and the assembly of the enclosure.
21 A thin layer of glue is applied to at least one flat side
22 of each layer before being set on the guide rods and
23 adjacent a previously set layer. The guide holes in the
24 top and bottom layers may be counter sunk as shown in
25 Figure 7 to accommodate the nut applied to each end of the
26 guide rods and under the condition of the last layer being
27 assembled the nuts tightened to hold the layers together
28 while the glue dries. After the final tightening, the nuts
29 may be sealed to the ends of the guide rods.

30 Figure 9 shows a top view of the stack of layers
31 shown in Figure 8.

32 Figure 10 is a cross-section of the stack of
33 layers taken along line a-a showing the formation of the
34 tuned base chamber 118 and the tuned mid-range and tweeter
35 chamber 119.

1 A layer of mesh or speaker cloth may be applied
2 to the outside surface of layer A. In the preferred
3 embodiment, a thin frame fabricated to be conforming with
4 circumferential edge 101 is covered with speaker cloth and
5 opposing hook and loop material are applied to the frame
6 and to layer A to removably attach the speaker cloth over
7 the preselected set of speakers mounted within the
8 enclosure.

9 If a crossover network is desired to enhance the
10 sound reproduction ability of the preselected set of
11 drivers, the electronics are designed using well known
12 prior art methods. The electronics for the crossover
13 network may be mounted on an integrated circuit board along
14 with internal connections to the drivers and external
15 connections accessible to the user to attach the user's
16 sound generation equipment. The integrated circuit board
17 is mounted on layer F.

18 In the preferred embodiment, each layer is
19 fabricated of three-quarters inch MDF with adjacent
20 circumferential layer edges, external or internal formed
21 within 1/32 of an inch of adjacent layer circumferential
22 edges thereby forming relatively smooth edge surfaces upon
23 stacking the layers in the preselected order.

24 In the preferred embodiment, the layers are cut
25 with a band saw, laser, or router to produce a sooth edge
26 without any raised portions. To insure that adjacent
27 layers fit tightly, after cutting, each layer may be edge
28 sanded to remove any protrusions that may cause separation
29 of any portion of the adjoining surfaces of the layers.

30 The first step in the process is to create a
31 general shape template such as that depicted in Figure 1
32 having the preselected external circumferential edge 101.
33 This process is similar to taking a cross-section of an
34 object that defines the preselected outside shape of the
35 enclosure. A plurality of guide holes 105 is applied to
36 this general template with preselected spacing between the

1 guide holes having the guide holes spaced apart from the
2 circumferential edge defining the outside shape of the
3 enclosure and any internal shapes. The layout of the guide
4 holes 105 is applied to each of the other templates to
5 insure alignment of each successive layer.

6 The nominal layers may be called a front cap and
7 a back cap separated by a preselected number of layers that
8 may be called hollow layers, cross-brace layers,
9 compartment layers, combination cross-layer and compartment
10 layers, and compartment cap layers. Each layer having a
11 circumferential shape 101 similar to the general shape
12 template and having the guide holes 105 marked on each
13 template. The guide holes 105 are formed as 1/8-inch holes
14 positioned a nominal distance of 1/4 to 2 inches from the
15 outside edge generally centered between the external and
16 internal circumferential edges. The number and placement
17 of the guide holes 105 is selected to create essentially
18 even intervals between adjacent guide holes 105 and placed
19 on a non-interference basis with internal chambers and
20 channels as well as to not weaken baffles, supports or
21 covers. In the preferred embodiment, the guide holes 105
22 are spaced 10 to 12 inches apart.

23 The most important internal cavities are the
24 separate compartments for the drivers 118 and 119. Each
25 driver has a set of theil-small parameters and serves a
26 different purpose for the overall sound generation. The
27 calculation of the cavity volume may be performed by
28 methods well known in the art. Each cavity 118 and 119
29 should be tuned to produce a flat frequency response for
30 the driver mounted in that cavity. With this method, a
31 test module may be produced, assembled and test module
32 subjected to measurement of sound reproduction capability
33 using known acoustical methods. Corrections to the
34 cavities 118 and 119 may then be calculated and the
35 internal shape of the templates forming the cavities
36 adjusted to form the desired tuned cavity shape all without

1 major rework of the entire design and disruption of the
2 external shape 101. This final set of templates is then
3 used to exactly reproduce the desired, tested and tuned
4 device.

5 The process of adding sound absorbing material
6 within a speaker enclosure is well known in the art and may
7 be used to further enhance the sound reproduction ability
8 of the individual drivers preselected to be mounted within
9 the enclosure fabricated by the method disclosed by this
10 invention.

11 A solid divider layer should terminate the
12 internal cavities. Thus, an opening for a shaped cavity
13 may be initiated in any layer, the number of layers having
14 this opening is continued until the cavity is formed of the
15 preselected volume and the resulting volume tested and
16 tuned as above. A solid layer is then used to cap the
17 cavity and separate the cavities formed in subsequent
18 layers. In the preferred embodiment, the exact volume
19 desired for a driver is calculated using available software
20 programs. The placement of the drivers with the tuned
21 cavities is selected whereby the cavities do not overlap on
22 the inside nor cause a breach of the outside surface other
23 than the opening in the outside surface into which the
24 driver is mounted.

25 Should the placement of the tuned cavities tend
26 to create structural integrity issues, a preselected layer
27 may be formed to include supports 107 for cross bracing at
28 preselected positions. In the preferred embodiment the
29 cross bracing is placed in the compartment divider layers
30 in order to provide structural integrity yet not interfere
31 with the volume of the internal cavity nor restrict the
32 mounting of the drivers within the opening of the cavities.

33 In the preferred embodiment, the individual
34 layers are cut from $\frac{3}{4}$ inch medium-density fiberboard (MDF)
35 chosen to be strong and to resist warping, twisting or
36 uneven expansion and contraction.

1 Upon gluing and assembly of the layers as aligned
2 on the guide rods 110 inserted within the guide holes 105,
3 tension is applied to the layers by tightening of nuts
4 engaged on the threaded ends 111 of the guide rods 110 to
5 produce even compression so as to not warp or distort
6 portions of the device.

7 The nuts are tightened sufficiently to hold the
8 layers in alignment, especially while the glue dries. No
9 further adjustment to the nuts should be necessary. Upon
10 drying of the glue, the nuts may be sealed to the ends of
11 the guide rods 110 to prevent loosening from the ends of
12 the guide rods 110 and release of the tension.

13 By using the method taught by this invention the
14 user may assembly a unitary enclosure that includes
15 internal chambers, channels, supports and baffles. In the
16 prior art if an internal wall needed to be added to the
17 enclosure device, it was accomplished by the addition of
18 additional structure secured to the existing internal walls
19 of the device. If the placement of this additional
20 internal wall mal-affected the sound reproduction ability,
21 the device had to be disassembled and the internal wall
22 remounted and the external surfaces reassembled.

23 With the present invention, the internal
24 supports, baffles, reinforcements and channels are formed
25 as an integral part of the construction and firmly held in
26 alignment by the guide rods 110. Once assembled, these
27 internal layers will not become dislodged.

28 After the layers have been assembled, the
29 resulting inside surface may be sanded to produce a smooth
30 surface. The outside surface may be particularly sanded
31 smooth to produce a surface upon which a veneer layer of
32 preselected finished may be glued. In the preferred
33 embodiment, the veneer is glued with heat-activated glue
34 that produces a strong, seam free covering. This external
35 veneer may be fabricated to have a grain and color to

1 complete the furniture like appearance of the enclosure
2 device.

3 Since certain change may be made in the above
4 apparatus without departing from the scope of the invention
5 herein involved, it is intended that all matter contained
6 in the above description, as shown in the accompanying
7 drawing, shall be interpreted in an illustrative, and not a
8 limiting sense.

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